

UNCLASSIFIED

---

AD 277 599

*Reproduced  
by the*

ARMED SERVICES TECHNICAL INFORMATION AGENCY  
ARLINGTON HALL STATION  
ARLINGTON 12, VIRGINIA



---

UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

# ~~Aerjet~~-General CORPORATION

AZUSA, CALIFORNIA

---

I N F O R M A L   R E P O R T   O F   P R O G R E S S

---

Copy No. 12

25 June 1962

TO:           Commanding General  
              Frankford Arsenal  
              Philadelphia 37, Pennsylvania  
  
              Attention:   ORDEA, H. Rosenthal

SUBJECT:      Investigation of Stress-Corrosion Cracking  
              of High-Strength Alloys

CONTRACT:    DA-04-495-ORD-3069

PERIOD  
COVERED:     1 May through 31 May 1962

This is the sixteenth in a series of informal progress reports  
submitted in partial fulfillment of the contract.

AERJET-GENERAL CORPORATION



R. F. Kimpel  
Head, Metallics & Refractories Section  
Research and Engineering Dept.  
Structural Materials Division

NOTE:       Information contained herein is regarded as preliminary  
              and is subject to further checking, verification, and analysis.

CATALOGED BY ASTIA  
AD 40

277 599

277599

I. OBJECTIVES

The objectives of this program are:

A. To study the susceptibility to stress-corrosion cracking of rocket-motor case materials: e.g., Vascojet 1000, 300M, and Ladish D6AC steels, AM355 and PH15-7Mo stainless steels, and B120VCA titanium.

B. To study the environmental parameters, including the atmosphere outside and inside the rocket case, that affect the rate and extent of stress corrosion.

C. To determine the effect of material parameters (composition, strength level, welding, microstructure, surface conditions, etc.) on the stress-corrosion process.

D. To devise and evaluate techniques for preventing the stress-corrosion cracking of rocket-motor case materials.

II. WORK PROGRESS

A. UNWELDED SPECIMEN TESTS

Both bent-beam and U-beam specimens were employed in evaluating the susceptibility to environmental stress-corrosion cracking of unwelded samples of the candidate alloys. A comprehensive summary of the bent-beam specimen test results is given in Table 1, and of the U-bend specimen test results in Table 2. The bent-beam specimens were stressed to 75% of the yield strength, and the U-bend specimens were bent over 12T- and 24T-diameter mandrels. The specimens were then exposed to environments representative of those that would exist during some phase of the manufacturing, testing, and long-term storage of solid-rocket-motor chambers. These tests were completed, and the data accumulated is quite indicative

of which alloys are susceptible to stress-corrosion cracking in the environments tested and of which environments induce stress-corrosion cracking of the alloys tested.

B. WELDED SPECIMEN TESTS

Welded bent-beam specimens of Ladish D6AC, 300M, and Vascojet 1000 steels, and of Bl20VCA titanium alloy were prepared; environmental testing is expected to begin shortly.

C. COATED SPECIMEN TESTS

Three protective coatings are currently being evaluated, two of epoxy-type and one a urethane-type coating. A summary of the environmental test data accumulated to date is given in Table 3. Specimens are currently being prepared with two other coatings, one a vinyl-type, and the other a zinc-filled coating. Environmental testing of these specimens will begin as soon as received from the coating vendors.

III. FUTURE WORK

A. Continuation of the environmental stress-corrosion testing of coated bent-beam specimens.

B. Environmental stress-corrosion testing of welded bent-beam specimens.

**TABLE 1**  
**BENT-BEAM STRESS-CORROSION TEST**

Alloy	Yield Strength 0.2% Offset psi x 10 <sup>-3</sup>	Air		Distilled Water		Tap Water		0.25% Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> Solution		1% Marquench Salt Solution		3% NaCl So	
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
Ladish D6AC	197.5	3	NF-28**	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	222.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	222.5	-	-	-	-	-	-	-	-	-	-	-	
	222.5	-	-	-	-	-	-	-	-	-	-	-	
	235.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	235.0	3	NF-298	1	NF-298	6	NF-298	3	NF-104	3	NF-104	3	
	235.0	-	-	1	103.8	-	-	-	-	-	-	-	
	235.0	-	-	1	125.0	-	-	-	-	-	-	-	
	235.0	-	-	1	138.7	-	-	-	-	-	-	-	
	235.0	-	-	1	148.7	-	-	-	-	-	-	-	
	235.0	-	-	1	165.7	-	-	-	-	-	-	-	
	252.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	252.0	3	NF-298	1	NF-298	1	151.0	3	NF-104	3	NF-104	3	
	252.0	-	-	1	84.0	1	151.7	-	-	-	-	-	
	252.0	-	-	1	95.8	1	151.7	-	-	-	-	-	
	252.0	-	-	1	112.0	1	155.1	-	-	-	-	-	
	252.0	-	-	1	113.0	1	185.7	-	-	-	-	-	
	252.0	-	-	1	118.7	1	186.7	-	-	-	-	-	
300M	196.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	196.0	-	-	-	-	-	-	-	-	-	-	-	
	196.0	-	-	-	-	-	-	-	-	-	-	-	
	213.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	213.0	-	-	-	-	-	-	-	-	-	-	-	
	213.0	-	-	-	-	-	-	-	-	-	-	-	
	233.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	233.0	-	-	1	84.0	1	151.7	-	-	-	-	-	
	233.0	-	-	1	139.0	1	151.7	-	-	-	-	-	
	233.0	-	-	1	171.9	1	186.7	-	-	-	-	-	
Vascojet 1000	194.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	212.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	237.5	3	NF-28	1	7.6	1	13.7	3	NF-21	3	NF-21	1	
	237.5	-	-	1	7.8	1	14.7	-	-	-	-	1	
	237.5	-	-	1	7.9	1	15.7	-	-	-	-	1	
	240.0	3	NF-28	1	1.8	1	2.7	3	NF-21	3	NF-21	1	
	240.0	-	-	1	3.2	1	8.8	-	-	-	-	1	
	240.0	-	-	1	4.3	1	9.7	-	-	-	-	1	
AM355	(T)199.0***	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	
	(L)250.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)250.0	-	-	3	NF-298	3	NF-298	-	-	-	-	-	
	(L)278.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)278.5	-	-	3	NF-298	3	NF-298	-	-	-	-	-	
PH 15-7 Mo	199.5	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
	225.0	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
	237.0	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
B120VCA Titanium	(L)137.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)139.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	
	(T)139.5	-	-	-	-	-	-	-	-	-	-	1	
	(T)139.5	-	-	-	-	-	-	-	-	-	-	1	
	(T)145.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)145.5	-	-	-	-	-	-	-	-	-	-	-	
	(L)149.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)158.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)166.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)166.0	-	-	3	NF-298	3	NF-298	-	-	-	-	-	

\* Stressed to 75% of the 0.2% offset yield strength.

\*\* NF-28 = no failure in 28 days.

\*\*\* T = transverse, L = longitudinal.

TABLE 1

BENT-BEAM STRESS-CORROSION TEST DATA\*

Environment													
1% Marquench Salt Solution		3% NaCl Solution		Trichloroethylene		Cosmoline		4% Soluble Oil Solution		High Humidity		Solid Propellant	
No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-181	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	NF-181	-	-
-	-	-	-	-	-	-	-	-	-	1	57.0	-	-
-	-	-	-	-	-	-	-	-	-	1	61.7	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	23.0	6	NF-134
3	NF-104	3	NF-104	3	NF-104	3	NF-104	3	NF-104	1	23.2	-	-
-	-	-	-	-	-	-	-	-	-	1	26.7	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	5.7	6	NF-134
3	NF-104	3	NF-104	3	NF-104	3	NF-104	3	NF-104	1	7.0	-	-
-	-	-	-	-	-	-	-	-	-	1	14.2	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	18.1	-	-
-	-	-	-	-	-	-	-	-	-	1	25.7	-	-
-	-	-	-	-	-	-	-	-	-	1	32.9	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	3.9	-	-
-	-	-	-	-	-	-	-	-	-	1	6.9	-	-
-	-	-	-	-	-	-	-	-	-	1	19.8	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	2.7	6	NF-134
-	-	-	-	-	-	-	-	-	-	1	3.9	-	-
-	-	-	-	-	-	-	-	-	-	1	4.8	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
3	NF-21	1	6.9	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
-	-	1	10.0	-	-	-	-	-	-	-	-	-	-
-	-	1	10.1	-	-	-	-	-	-	-	-	-	-
3	NF-21	1	1.2	3	NF-21	3	NF-21	3	NF-21	-	-	4	NF-134
-	-	1	1.7	-	-	-	-	-	-	-	-	1	99.0
-	-	1	6.7	-	-	-	-	-	-	-	-	1	118.0
3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-81	6	NF-141
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	6	NF-141
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	2	NF-111	-	-
3	NF-21	1	NF-21	2	NF-21	3	NF-21	3	NF-21	2	NF-111	-	-
-	-	1	0.0+	1	3.4	-	-	-	-	-	-	-	-
-	-	1	0.03	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	2	NF-21	3	NF-21	3	NF-21	3	NF-111	-	-
-	-	-	-	1	0.9	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	6	NF-141
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	6	NF-141
-	-	-	-	-	-	-	-	-	-	-	-	-	-

2

Table 1

TABLE 2  
U-BEND STRESS-CORROSION TEST DATA

Alloy	Yield Strength 0.2% Offset $\text{psi} \times 10^{-3}$	Environment									
		Distilled Water		Tap Water		0.25% $\text{Na}_2\text{Cr}_2\text{O}_7$ Solution		1% Merguach Salt Solution		3% NaCl Solution	
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
Ladish D6AC	197.5	1	NP-261*	2	NP-347	2	NP-347	2	NP-261	2	NP-347
	197.5	1	167.6	-	-	-	-	-	-	-	-
	222.5	1	137.3	2	NP-261	2	NP-347	2	NP-261	2	NP-347
	222.5	1	141.7	-	-	-	-	-	-	-	-
	235.0	1	20.2	1	33.3	1	NP-347	2	NP-347	1	62.4
	235.0	1	32.9	1	189.6	-	-	-	116.5	-	-
300M	252.0	1	18.4	1	28.9	2	NP-347	1	18.5	1	NP-347
	252.0	1	22.4	1	39.9	-	-	1	259.1	-	-
	196.0	1	111.7	2	NP-261	2	NP-347	2	NP-347	2	NP-347
	196.0	1	193.5	-	-	-	-	-	149.4	-	-
	213.0	1	18.4	2	NP-261	2	NP-347	2	NP-347	1	11.3
	213.0	1	34.9	-	-	-	-	-	40.9	-	-
Vascojet 1000	233.0	1	14.4	1	22.4	2	NP-347	1	182.7	1	11.3
	233.0	1	34.9	1	29.1	-	-	1	217.5	1	26.5
	194.0	1	140.7	1	140.7	2	NP-347	2	NP-347	1	NP-282
	194.0	1	181.5	1	163.4	-	-	-	49.9	-	-
	212.0	1	14.7	1	60.4	2	NP-347	2	NP-347	1	13.7
	212.0	1	141.7	1	69.4	-	-	-	53.3	-	-
-	240.0	1	4.4	1	7.4	2	NP-347	1	273.0	1	4.3
	240.0	1	11.4	1	19.5	-	-	1	276.0	1	6.8

\* NP-261 = no failure in 261 days.

Table 2